

*Original Article***Effect of postural combinations—the reclined seated position combined with head rotation—on the transport of boluses and aspiration**

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**ABSTRACT**

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**Purpose:** The purpose of this study was to determine combinations of compensatory postural maneuvers used for dysphagic patients that could increase the risk of aspiration.

**Methods:** Study 1: The pathway of the transported bolus was examined in various combinations of 30° head flexion, head rotation to the right (0°, 30°, or 60°) and reclined seated position (90°, 60°, or 45°) by using synchronized imaging of videofluoroscopic (VF; AP view) and videoendoscopic (VE) evaluation of swallowing in 5 healthy volunteers (24–45 years). Study 2: The occurrence of aspiration was evaluated in combinations of 30° head flexion, head rotation (0° and 30° left and right), and a reclined seated position (90°, 60°, or 45°) by using VF lateral view in 10 dysphagic patients (74.7 ± 6.7 years).

**Results:** Study 1: In a combined posture of 45° in a reclined seated position with a 30° head rotation to the right, the bolus reached the pyriform sinus on the side

of rotation before the onset of the swallowing reflex in 2 of the 5 healthy volunteers. Study 2: The aspiration rate was highest (40%) at a combined posture of 30° head rotation and 45° reclined seated position.

**Conclusion:** These findings suggest that certain postural combinations may increase the risk of aspiration.

**Key words:** dysphagia, aspiration, posture, rehabilitation, stroke

**Introduction**

Stroke patients often develop dysphagia and sometimes develop aspiration pneumonia. To prevent aspiration, dysphagic stroke patients usually undergo a program of comprehensive swallowing rehabilitation, which involves the provision of suitable food, oral hygiene, and direct and indirect swallowing training; such programs have been implemented in many hospitals.

Among the treatments for dysphagic patients, postural maneuvers while eating are an effective means of swallowing safely without aspiration; these maneuvers include a reclined seated position, head flexion, and head rotation, which are typically used as posture compensation techniques [1]. Such posture compensation techniques are used in direct training or daily meals, and effects have been reported in the reduction of retention in the pyriform sinus after swallowing and the prevention of aspiration [2–4].

With regard to the compensatory effects of the reclined seated position for dysphagia, it has been reported that reclining at an angle of 60°, 45°, or 30° is advantageous in reducing the occurrence of aspiration compared with the seated upright position [5–7]. The bolus is thought to enter the pharynx from the mouth when in the reclined seated position, and reaches the pyriform sinus to trigger the swallowing reflex, so that the risk of aspiration is reduced.

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Head flexion, the so-called chin-down position, is a typical technique used as a compensatory measure to prevent aspiration. The mechanism is for head flexion to increase tongue pressure during swallowing, which results in reduced retention of the bolus in the vallecula and pyriform sinus, and compensates for delayed larynx closure [8–10].

Head rotation induces the bolus to pass through the pyriform sinus on the opposite side to reach the esophagus. As a result, the bolus passes via the healthy side, bypassing the damaged side of the pharynx and pyriform sinus, and more efficient swallowing is enabled. This technique has been reported to be particularly effective in dysphagic patients with unilateral paralysis of the pharynx, larynx, and vocal cords following resection of a tumor in the lower pharynx, and those with nerve paralysis in similar regions [11–12].

Thus, although clinical reports have described the beneficial effects of each of the compensatory swallowing techniques (the reclined seated position, head flexion, and head rotation) in preventing aspiration in dysphagic patients, no studies have reported on the effects of these postures in combination on swallowing in dysphagic patients. We focused on head rotation and the reclined seated position, which are frequently used clinically as compensatory swallowing techniques, and examined the effects of those combinations on the bolus pathway and swallowing. The effects of postural combinations at different angles on the bolus pathway were evaluated by synchronized imaging of videoendoscopic (VE) and videofluoroscopic (VF) evaluation of swallowing in healthy volunteers. In addition, the effects of these postural combinations on dysphagic patients were evaluated based on the occurrence of aspiration of test food using VF (lateral view).

**Ethics:** All subjects gave written informed consent that they understood the study as described to them and that they were willing to participate. The contents of the study were approved by the ethics committee.

## Subjects and Methods

### 1. Study of postural combinations in healthy volunteers (Study 1)

The subjects were 5 healthy male volunteers aged 24–45 years. Paste-like barium (100 ml of Barytogen Sol® 50% wt/vol from Fushimi, Kagawa, Japan, containing 2 g of thickener, Toromerin-Hi®, from Sanwa SKK, Aichi, Japan) was used for the study. The subjects were administered 8 ml of paste-like barium by mouth and were verbally instructed to chew and swallow freely. Swallowing of the bolus was recorded by VF (AP view) and VE (Olympus ENF Type P4®), which were used to capture synchronized video images (Digital video, 30 frames/s). The pathway of the transported bolus from the mouth to the oropharynx to

the pyriform sinuses in 9 different combinations of postures was examined using synchronized imaging by VF and VE. In addition, the sites reached by the bolus when the swallowing reflex occurred were identified. In order to correctly place the subjects in the 9 different postural combinations, a chair specifically designed for VF (VF-MT-1®, Tomeibrace) was used. The seat of this chair can be moved up and down electrically and a backrest can be moved manually and continuously to give an angle of recline from 0° to 90°. In addition, a headrest with a goniometer that displays the angle was attached to the backrest, to allow us to set the angle of head rotation at 30° or 60°. The angle of head rotation was determined by the following method. The subject's head was covered with a mask, and a line was drawn on the mask passing through the bilateral external acoustic meatus and the top of the head, and a perpendicular line was drawn through the bridge of the nose. Based on these reference lines, the rotational angle of the head was determined using the goniometer attached to the headrest. The 9 combinations of posture that were evaluated were as follows: a reclining angle of 45°, 60°, or 90° (upright sitting position) from the horizontal position combined with a head rotation angle to the right of 0°, 30°, or 60°, with the head flexion angle fixed at 30° for all 9 combinations. As regards the direction of head rotation, it was impossible to rotate the head to the left because of the position of the X-ray unit used for synchronized imaging of VF (AP view) and VE. Because of this technical limitation in VE evaluation, the study was conducted with head rotation only to the right.

### 2. Study of postural combinations in dysphagic patients (Study 2)

The subjects of Study 2 were 10 patients who had undergone VF prior to this study and had been diagnosed with “3: liquid aspiration” according to the Dysphagia Severity Scale (DSS). All were male and the mean age was  $74.7 \pm 6.7$  years. All patients had been diagnosed with multiple lacunar infarctions of the brain by MRI. This study was intended to clarify the effect of combinations of postures on aspiration. The purpose and risks were explained in writing to all patients and written consent was obtained. In Study 2, subjects were seated in the VF chair used in Study 1 and the pathway of the transported bolus, together with the occurrence of aspiration, was examined using a VF lateral view. The test food was 4 ml of paste-like barium (as used in Study 1). It was placed on the tongue and the subjects were instructed verbally to chew and swallow freely. The 9 different combinations of posture used in study 2 were as follows: a reclining angle of 45°, 60°, or 90° (upright sitting position) from the horizontal position combined with a head rotation angle of 0° or 30° to the right or left. The head flexion angle was 30° for all 9 combinations. When there was a difference in the bolus pathway or occurrence of

aspiration between the right and left head rotations, the influence of the differences in laterality of the cervical spine or the pharyngeal paralysis were examined by adding a VF AP view.

#### Statistical analysis

Fisher's exact test was used to compare the incidence of aspiration evaluated by VF imaging between the head rotation of 30° and 0° in each of the reclining positions in the dysphagic patients. A p value less than 5% (two-tailed test) was considered statistically significant.

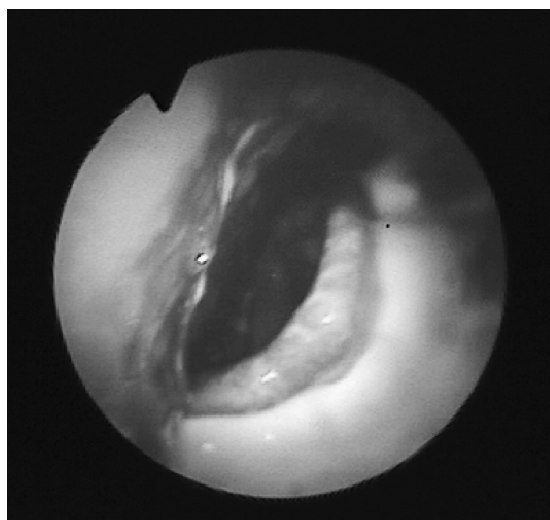


Fig. 1-A



Fig. 1-B

#### Figure 1.

The bolus pathway during swallowing in one of the healthy adult volunteers in the reclined seated position of 45° with head rotation of 60° to the right (The upper photograph in 1-A was captured by VE and the lower in 1-B was captured by VF (AP view). The images are synchronized.)

## Results

### 1. Study of postural combinations in healthy volunteers (Study 1)

The 5 healthy volunteers seated in an upright position at 90° were administered test food (barium paste, 8 ml) in the mouth and verbally instructed to chew and swallow freely. In combinations of postures of upright sitting at 90° and head rotation to the right at 0°, 30°, and 60°, the swallowing reflex occurred in all subjects when the barium bolus reached the vallecula, and it was then transported to the esophagus. The bolus did not reach the pyriform sinuses on either



Fig. 2-A

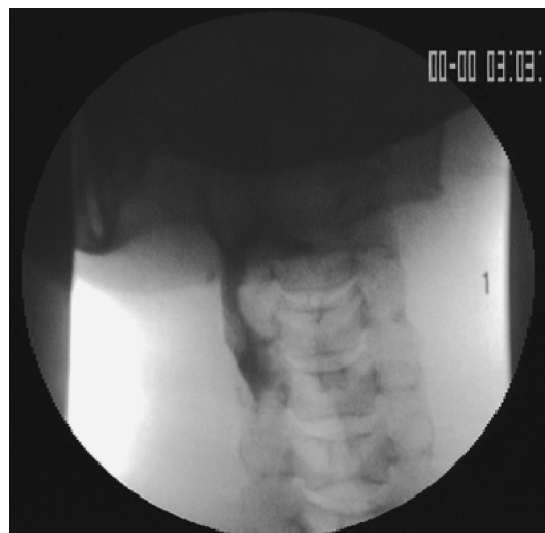


Fig. 2-B

#### Figure 2.

The bolus pathway during swallowing in one of the healthy adult volunteers in the reclined seated position of 45° with head rotation of 30° to the right (The upper photograph in 2-A was captured by VE and the lower one in 2-B was captured by VF (AP view). The images are synchronized.)

side prior to the onset of the swallowing reflex (Figures 1A and 1B).

Similarly, when the subjects reclined at an angle of 45° or 60° from the horizontal position, with a head rotation of 60° to the right, in all subjects the bolus reached the vallecula before the onset of the swallowing reflex but did not reach the pyriform sinus on the side of the rotation. After the onset of the swallowing reflex, the bolus was transported from the vallecula through the contralateral pyriform sinus to the esophagus.

However, in the combination of postures in which the subject was in a reclining position at an angle of 45° and a head rotation of 30° to the right, a portion of the bolus reached the pyriform sinus on the side of the rotation before the onset of the swallowing reflex and passed into the esophagus through the pyriform sinuses on both sides after the swallowing reflex in 2 (40%) of the 5 healthy subjects (Figures 2A and 2B).

## 2. Study of postural combinations in dysphagic patients (Study 2)

Evaluation by a VF lateral view: the bolus (barium paste, 4 ml) reached the bilateral pyriform sinuses before the onset of the swallowing reflex in a normal position (an upright sitting position at 90° and head rotation at 0°) in 8 (80%) of 10 dysphagic patients. The bolus reached the bilateral pyriform sinuses before the onset of the swallowing reflex in the combination of postures in which there was a reclining position at any angle and a head rotation at 30° in all patients. Among these patients, 4 (50%) showed retention of the bolus in the pyriform sinus on the side of rotation after the swallowing reflex.

Table 1 shows the frequency of occurrence of aspiration in different postural combinations. In the postural combinations without head rotation (an angle of 0°), aspiration of the retained bolus occurred after the swallowing reflex in 4 patients who were in the upright position, in 1 patient who was reclining at a 60° angle, and in none of the patients when in the 45° reclined seated position. However, aspiration occurred in 4 patients in a combination of the 45° reclined seated position with head rotation of 30° (2 patients with rotation to the right side and 2 patients with rotation to

the left side). These 4 patients were the same patients who showed retention of the bolus in the pyriform sinus after the swallowing reflex in the postural combination of upright seated position with head rotation. In one of these 4 patients, compression of the pharynx by an osteophyte of the cervical vertebrae (C6/7) was noted just above the entrance of the esophagus and retention of the bolus in the pyriform sinus was aspirated during the subsequent swallowing. In the other 3 patients, retention of the bolus in the pyriform sinus on the side of rotation was aspirated into the larynx during inspiration, which was determined to be aspiration after swallowing.

## Discussion

Postural maneuvering while feeding is a beneficial compensatory approach that enables dysphagic patients to eat safely. The effectiveness of these postural maneuvers has been reported for each posture. However, the effects of combinations of postures have not been reported. In actual clinical situations, a combination of postures is often used; however, it has been reported that there may potentially be an increased risk of aspiration unless the most appropriate combination is chosen for each individual patient [13]. These types of clinical experience prompted us to conduct this study in order to clarify the effects of combinations of postural maneuvers on the pathway of the bolus, timing of the swallowing reflex, retention after swallowing, and the occurrence of aspiration.

“Chewing and swallowing,” where subjects swallow freely while chewing the test food, is the method we used in this study. There are 2 reasons for adopting this approach. The first is to evaluate the pathway of the bolus immediately before the swallowing reflex using VE. The “command swallow” has been used widely to evaluate swallowing difficulties using VF and VE. However, the swallowing reflex occurs before the bolus reaches the vallecula with the “command swallow” approach [1], which makes it difficult to use VE to observe the passage of the bolus just before swallowing. On the other hand, the bolus may reach the vallecula and pyriform sinus during chewing using

**Table 1.** Changes in the frequency of aspiration under different postural combinations

	Angle of the reclined seated position (angle from the horizontal position)		
	90° (upright)	60°	45°
Angle of head rotation: 0°	4	1	0
Angle of head rotation: left or right: 30°	4	2	4*

· The numbers represent the number of patients among 10 dysphagic patients who were diagnosed by VF to have aspiration with administration of 4 ml of barium paste.

\*p < 0.05 (Fisher's exact test)



the “chewing and swallowing” approach [14], which makes it possible to observe the passage of the bolus just before swallowing using VE. The second reason is that swallowing while chewing is often seen during actual eating. It was determined that “chewing and swallowing” would serve the purpose of this study to evaluate the risk of aspiration in dysphagic patients.

With the combination of reclining at 45°, 30° head flexion, and 30° head rotation to the right in Study 1, a portion of the bolus reached the pyriform sinus on the side of rotation before the onset of the swallowing reflex in 2 of 5 volunteer subjects. This suggested that it might be difficult to use this combination as a means of compensation to prevent the bolus from passing through the pyriform sinus on the side of rotation. We have considered 2 possible reasons for this. First, the head tends to tilt towards the side of rotation in the frontal plane of the trunk with this combination compared with the combination with the upright seated position at 90°. As a result, the bolus tends to enter the pyriform sinus on the side of rotation from the vallecula on the same side. The original purpose of the combinations of postures is to enable the bolus to pass on the opposite side of rotation and it is important that the head tilts towards the opposite side of rotation in the frontal plane of the trunk. The second reason is that the closure of the pyriform sinus on the side of rotation is incomplete when the head rotation is at an angle of 30° compared with 60°. As a result, the bolus reaches the vallecula on the side of rotation, passes through the pyriform sinus on the side of rotation, and is swallowed into the esophagus. In Study 1, the subjects were healthy and aspiration did not occur with this combination of postures. However, this result suggested that this combination cannot prevent the passage of the bolus to the side of rotation (affected side) in dysphagic patients with unilateral paralysis or structural damage of the pharynx and, therefore, it could increase the risk of aspiration.

The results of Study 2 with 10 dysphagic patients revealed that, consistent with previous reports, a reclined seated position of 45° or 60° without head rotation reduced the incidence of aspiration more than the upright seated position. However, when a reclined seated position was combined with head rotation, the retention of the bolus on the side of rotation is increased depending on the angle of rotation and the risk of aspiration increased. The following reasons are thought to be involved in the increased incidence of aspiration with these combinations in dysphagic patients. Because the head rotation was at 30°, closure of the pyriform sinus on the side of rotation was incomplete, such that the bolus reached the pyriform sinus on the side of rotation before the onset of the swallowing reflex and a greater amount of the bolus remained there after swallowing. As a result, retention in the pyriform sinus in dysphagic patients led to aspiration during subsequent swallowing or aspiration after swallowing

during inspiration into the larynx.

The reasons why the combination with head rotation at 60° was not evaluated in Study 2 were as follows: in Study 2, it was deemed important to identify postural combinations in which aspiration is likely to occur clinically. It was found in Study 1 that the bolus was likely to reach the pyriform sinus before the swallowing reflex with a combination of head rotation at 30° and the reclined seated position. Therefore, head rotation at 30° was used. As it was necessary to evaluate the head rotation on both sides using a lateral view because of differences in laterality in the passage of the bolus in patients, a combination of head rotation at 60° with the reclined seated position was not evaluated, to reduce the amount of radiation exposure. Also, it is difficult to continue eating while maintaining head rotation at 60°, and the head rotation often reverts to approximately 30° during eating, which was a further reason why head rotation at 60° was not used.

Four dysphagic patients who aspirated with a postural combination of reclining at 45° and head rotation at 30° had multiple cerebral infarctions, although paralysis of the limbs showed no difference in laterality. However, the AP view of VF showed the differences and there were directions of rotation that tended to cause aspiration. This suggests that it is necessary to perform VF to determine whether a combination of head rotation and reclined seated position should be used, or to determine which direction is appropriate if head rotation is used.

As Logemann described [1] VF studies in healthy young adults demonstrate the onset of the swallowing reflex when the bolus reaches the inferior border of the mandible to the vallecula. However, in Study 1, a portion of the bolus reached the pyriform sinus on the side of rotation before the onset of the swallowing reflex in 2 of 5 young healthy subjects when in a postural combination of head rotation at 30° and a reclined seated position. In elderly or dysphagic patients, the onset of the swallowing reflex is likely to be delayed and the bolus may reach the pyriform sinus before the swallowing reflex begins, even when the “command swallow” is used. These observations suggest that a portion of the bolus easily reaches the pyriform sinus on the side of rotation before the onset of the swallowing reflex in dysphagic patients if they recline and rotate their head. The effects of postural combinations on dysphagia are not the sum of the effects of each postural maneuver, but the effect of the newly combined posture itself on dysphagia. It may be effective in feeding as a compensatory method, but may increase the risk of aspiration, such as was seen with the postural combinations in this study. It is necessary to evaluate swallowing in the newly combined posture using VF in order to select the right combination to suit the individual’s characteristics of dysphagia.

### Conclusion

It was found that the postural combinations with an inadequate angle of head rotation and a reclined seated position may increase the risk of aspiration in dysphagic patients because of the fact that a portion of the bolus passes through the side of rotation and remains in the pyriform sinus on the side of rotation. The results suggested that it is necessary to ensure safety using VF when determining the best postural combination for dysphagic patients.

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